Mediating (nonverbal) communication between persons with different cognitive abilities using interactive artifacts

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Abstract

In a time of increasing interest in living and supporting life with mental illnesses, social design offers new tools and solutions for improving human livelihood and well-being. This paper presents student projects completed for a social design course in 2017 and 2018 at the Estonian Academy of Arts that combine traditional crafts with interaction design mindset and skills, resulting in social design work that tackles nonverbal communication with and between persons with different cognitive abilities. The paper compares the development processes of student work for a social design course from two consecutive years, sheds light on the project evaluations, future use in the real life context, and allows for a discussion of the future of design for social interaction between persons with different cognitive abilities mediated by interactive artifacts. The process of involving multidisciplinary instructors team and medical specialist into the design education process is described and reflected on.

Author keywords

Social design; interaction design; textile design; e-textiles; crafting; touch-based interaction.

Introduction: multidisciplinary social design

Electronics merging with traditional crafts as e-textiles in the context of social design have gained more interest recently. For example, touch-based interaction for visual impairment (Giles & van der Linden, 2014) has shown potential in the workshop setting. Giles created space for blind and visually impaired people to be able to create personal interactive art objects. Students at the California College of the Arts have learnt about social design by developing items for people with permanent movement disorders of cerebral palsy (Grant, 2016). Blumenkranz et.al. (n.d.) have developed a kit that would facilitate "the creation of made-to-measure e-textile and wearable interfaces for people with physical disabilities." E-textiles have also been discussed in the context of cognitive development of people. In his PhD thesis ten Bhömer (2016) created a textile object with a goal to enable a dialogue between a person with dementia and his/her family member. Zhiglova (2018) discussed the socializing potential of the e-textile based interface from the Human Computer Interaction perspective by creating an interactive carpet for engaging with children with Autism Spectrum Disorder.

Opportunities of interactive textile based design for educational tools for children with various spectrums of alertness sensitivities were explored by Kuusk and Nimkulrat (2018). They discussed a social design course in spring 2017 in which the final year undergraduate Textile Design students at the Estonian Academy of Arts developed a set of interactive artifacts for the special-needs educators in the center of mental health of Tallinn Children's Hospital. The first part of this paper reports on the evaluation of the same set of interactive tools after nine months of use and the second part presents the outcomes of the same course taught one year later. In spring 2018 a new group of undergraduate students of varied design specialisms, including textile, fashion, product and leather accessory design) collaborated with a care center for adults with a wide spectrum of cognitive disabilities to develop items for the center's multi-sensory room (Long & Haig, 1992). A multidisciplinary team of tutors guided the student group: smart textile design-researchers, an HCI professional, a tutor from electronics workshop, and occasional feedback was provided by the care center employees. The students were encouraged to "learn to learn" – to develop the ability to learn from experience, to reflect, to self-regulate their learning, to take responsibility, and to assess themselves (Hummels & Lévy, 2013).

This paper attempts to reflect upon ways in which interactive artifacts may facilitate nonverbal communication with and between persons with different cognitive abilities after being put to work in actual environment with actual users. The paper retrospectively looks at student work completed during two consecutive years for a social design course and its future use in the real life context.

Evaluation of the student work used at Mental Health Center at Tallinn Children's Hospital

Interactive textile-based design for education tools for children with various spectrums of alertness sensitivities

Each year the social design project at Estonian Academy of Arts departs from a specific special education partner and their clients. In the spring of 2017 the students of Department of Textile Design brought their design artifacts that they had developed over the course of ten weeks for permanent use in the Mental Health Center at Tallinn Children's Hospital. Kuusk and Nimkulrat (2018) have described the process and resulting interactive artifacts with their motivations and references for developing qualities in detail. Below is a short contextual overview of the interactive artifacts.

UUDU (Figure 1 left) is a tool for color and pattern matching and texture exercises. Its soft hexagonal rotatable wheel divided into color and pattern sections was attached to the top part of the wooden panel painted in the respective colors and patterns, allowing color and pattern matching. In the bottom part of the panel there are rollers with interchangeable textures that allows for sensory awareness exercises (reaching, swiping, grasping).

SHPACO (Figure 1 middle) is a game for learning shapes, patterns, and colors. The surface is filled with soft switches of which each forms a pair of matching shapes, patterns, and colors. The child would find the pairs collaboratively with the instructor and lights would illuminate in case of the correct pair.

TEKK (Figure 1 right) is a multifunctional therapeutic blanket with weighted buckwheat sachets that could be altered and used in respect to the needed pressure or the function of the artifact. As a heavy blanket it provides anxiety relief. As a play mat it could develop balancing skills, mimic a massage, and arouse tactile senses. The herbal buckwheat pillows stimulate smell and tactile experiences.

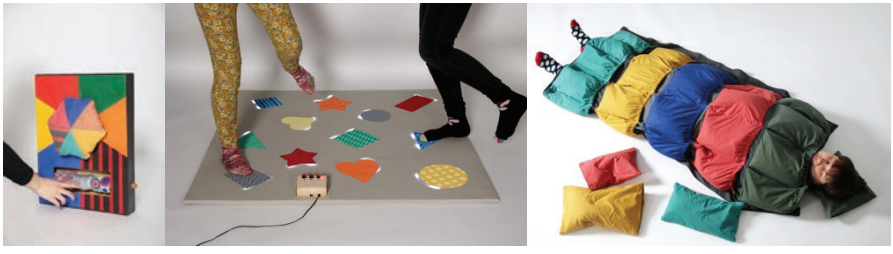

Figure 1. From left: *UUDU* by Helen Grass and Irina Pommer, 2017; *SHPACO* by Maria Teng, 2017; *TEKK* by Kris Veinberg and Egle Lillemäe. © Helen Grass, Irina Pommer, Maria Teng, Kris Veinberg, Egle Lillemäe, and Estonian Academy of Arts.

After the academic evaluation, the work stayed in the Mental Health Center at Tallinn Children's Hospital for the staff and client's daily use. The next section

will present the user comments and ideas that have emerged after the artifacts had been in use for nine months in the center.

Evaluation of the nine months of use of interactive artifacts in the Mental Health Center at Tallinn Children's Hospital

The previously described three works were delivered to the Mental Health Center at Tallinn Children's Hospital together with their accompanying digital video and PDF instructions of use. One staff member who is a special education specialist at the hospital was personally involved in the development process and took the initiative of introducing the works to her colleagues. The hospital staff member did not receive any specific instructions for documenting the use of the artifacts. They were informed about a possible follow-up request by the researchers in order to evaluate the long-term use of these artifacts created as social design course work. Nine months after the artifacts had been handed over one of the researchers contacted the hospital staff member for an open-ended interview at the hospital. The interview lasted approximately 1 hour.

The special education specialist at the Mental Health Center used the artifacts designed by the students continuously, in average 1-2 days a week. At the time of the evaluation *UUDU* was stored in her office where she meets her clients who are children with cognitive disabilities daily. She uses *UUDU* with a client whenever his/her cognitive level allows, mainly reaching sensory level communication. She used the different structures of *UUDU* and persuaded the client to attach and detach the textile surfaces on to the rollers with the Velcro. Children like Velcro in general. Some clients preferred arranging the patches, whilst some other preferred creating chaos with them. *UUDU* helped the clients who otherwise had struggled to maintain their attention. According to the specialist, *TEKK* was mainly used by the parents and a psychologist. She noted that the separate buckwheat pillows had been removed from the blanket to be used with smaller children. Sometimes they placed the pillows on the laps of the children, sometimes next to them. Children had also played hide-and-seek by using the sachets of the blanket. Therapists occasionally hid things into the sachets and children looked for them. *SHPACO* found less use at the Mental Health Center because the electronics had stopped working. It was also not working by the time of the visit.

According to the special education specialist, the items were interesting to the children during the nine months of use. As the clients saw and interacted with the artifacts maximum only once per week they have not lost their interest in the artifacts. Therapists also used the items in different ways, inventing new activities to play with the children. They alternated the use of the artifacts and in fact, the artifact was used only as a small part in the larger activity and goal of the session, so there was a lot of variety.

Over the course of nine months *TEKK* and its elements were used the most. Children found multiple ways of interacting with the artifact: building towers, playing pillow fight, and play hide-and-seek. Its multi-functionality generated the open ended and multipurpose use. It allowed for the creation of a mess or the organization of the space, which can be a very important exercise, particularly for autistic children.

Besides the therapists and other staff members, the items have been used by the parents of the clients. They are used for rewarding for evaluations and milestones.

For further development the special education teacher suggests to think of solutions for children to bring some of the educative tools back home with them.

Process of Designing Interactive Learning and Therapy Tools

In spring 2018 the social design course started again with a new special education partner and their clients. In the course, the groups of textile, product, and leather design students collaborated with the Support Center Juks in Tallinn. The organization serves the Social Welfare and Health Care Departments of Tallinn. It offers social services to intellectually disabled people and supports people with special needs to cope maximally in everyday life, vocational trainings and working life (Tugikeskus Juks, 2018). The Support Center had recently started accepting people with autism spectrum disorders and proposed that the focus of the collaboration with the students would be on a sensory room for their autistic clients.

The duration of the course was ten weeks. At the start of the course the tutor briefed the group of students about the principles of social design, examples of the previous year's student work, and information about the specific special education partner. The context of autism and various spectrums of alertness sensitivities were new to all participants. The students could form pairs or work individually. Out of nine students enrolled in the course, three decided to work individually and six paired up forming three groups. Five of the participating students were of Estonian background and the other four students came from various places in Europe. In the second class the group of the students together with their main tutor visited the Support Center. During the visit the staff of Juks provided the students with an overview of the work and environment at the Center and gave a lecture about autism spectrum disorders and guidance regarding some main directions to follow. The students were briefed about the general safety issues concerning people with autism, for example to avoid sharp edges where the users could harm themselves. Throughout the course the students met regularly with the main tutor as well as an expert in electronic prototyping. The electronic prototyping consultations were added to the process based on the experience in the previous year in which the technical issue had become a fundamental issue for a therapeutic tool to properly function. The students had one feedback session with the staff of Juks midway of the project and a final evaluation in which the academic tutors, Juks staff as well as potential clients participated.

The following section will showcase a selection of student projects completed for the social design course in 2018. The authors selected the projects based on their differences in idea, functionality and execution.

Seven Prototypes of Interactive Learning and Therapy Tools

Using the opportunities that textile and electronics can offer in conjunction with the needs of various spectrums of autistic sensitivities introduced by the

special education teacher at Juks, the students developed learning and therapy tools that the education specialists can use in their daily work with their clients.

Friendly Scarf

Friendly Scarf acts as a huggable friend and is meant to calm down, relieve stress, and give a safe feeling to the wearer (Figure 2). It is made of soft velveteen stretchable polyester-cotton fabric whose texture invites relaxation and comfort. The scarf integrates six vibration motors that activate when a snap button is closed. It encourages the user to practice eye contact (as it can be a difficult task for some people with autism) with the dog-looking end. The scarf has several alternative ways of wearing: on the shoulders, around the neck, over the head, covering the back etc. The two sides of the scarf are of different colors.

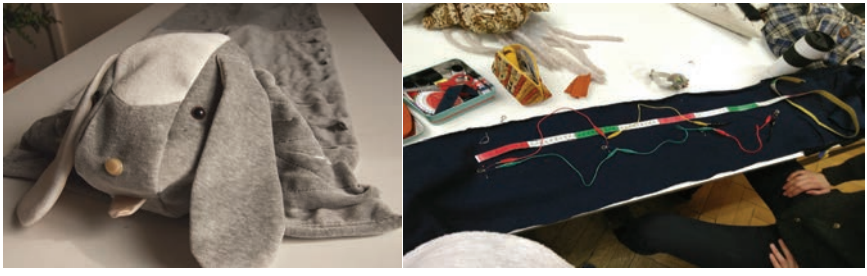

Figure 2. *Friendly Scarf* and a moment from its creation process by Indrė Milašiūtė and Laura Rusanen, 2018. © Indrė Milašiūtė and Laura Rusanen, and Estonian Academy of Arts.

To finalize *Friendly Scarf* the paired students combined their knowledge in textile materials and tools, such as machine and hand sewing, with their understanding of e-textiles to integrate electronic components, such as vibration motors, Arduino, battery, wires, etc. onto a textile substrate.

TELK

TELK ("telk" means "tent" in Estonian) is intended to be a calming space for the clients of Juks where they can relax and stimulate their senses by touching different textures. The students' creative intention is to give the user a feeling of staying under water. A projector LED night lamp fills inside the tent with calming ocean waves and sounds. The tent which hangs from a wall has 11 jellyfish. Five jellyfish are attached to the fabric next to the wall and six others to the fabric covering the other side (Figure 3). When touched the jellyfish vibrate subtly and show a colorful light.

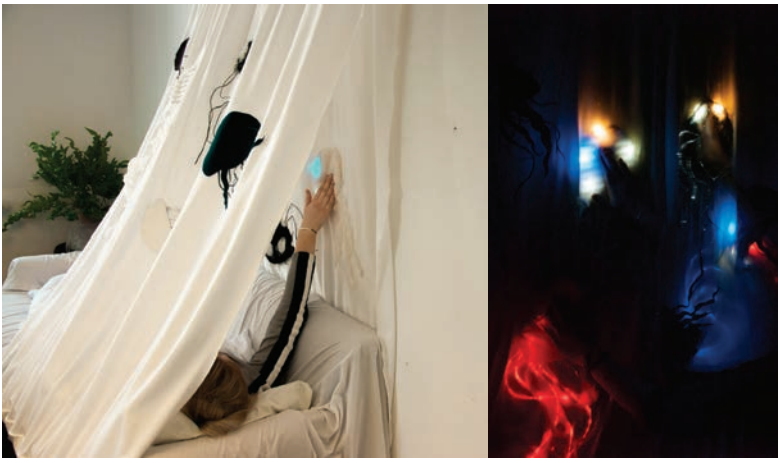

Figure 3. *TELK* in daylight and darkness by Karolin Innos, Lisandra Türkson, 2018. © Karolin Innos, Lisandra Türkson, and Estonian Academy of Arts.

TELK uses traditional textile skills of hand sewing to work with soft materials in a variety of textures and surfaces such as fabric, leather, metal grid, velvet, synthetic fur and integrates various electronic component such as vibrating motors, LEDs, fiber optic cables, and conductive thread.

Moodi

The stimulating game helps the client to learn and interpret the core emotions based on different facial expressions. This game consists of base faces and three facial parts of eyes, nose, and mouth. The user gets vibration feedback by finding matching couples and connected them. The elements are made of different soft textures such as cotton, wool and various types of fabric, using craft techniques such as hand sewing and crochet. The eyes are filled with dry rice and beans. Battery-powered vibration sensors are embedded in the fabric elements using conductive thread and conductive velcro to generate tangible feedback to the user. All related pairs can be attached to a blanket and used as a learning aid.

Figure 4. *Moodi* by Aylin Hackenberg, 2018. © Aylin Hackenberg, and Estonian Academy of Arts.

Off Line

Off Line is a kit that helps people with anxiety to relax. Based on her personal experience the student observes how people act when feeling anxious. She noticed a behavior of tearing papers, tissues in the pockets, and in general the habit of touching and holding things (keys, phone, hairbands, coins, lighter, etc.) in the pockets. Inspired by that, she designed a kit of six small artifacts that fit into one's hand and potentially release anxiety. Two of the artifacts include electronic components. The artifacts have four different textures and shapes.

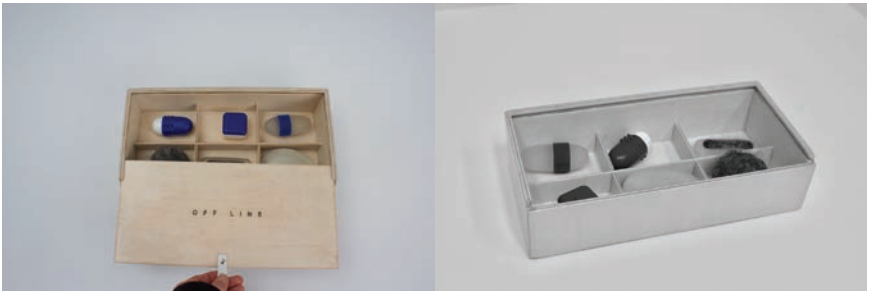

Figure 5. *Off Line* by Ann Müürsepp, 2018. © Ann Müürsepp, and Estonian Academy of Arts.

Materials of various tactile qualities were used to create *Off Line* including wool felt, foam, silicon, and Velcro. Programming and prototyping skills are important for the making of these artifacts.

MoveColour

MoveColour is a touchable light-playing board for people with autism spectrum disorders. This product is for increasing their ability to concentrate and memorize. It is also a pleasurable help for creative thinking and self-expression. There are different ways to play with it: the client can play with it alone or with the teacher.

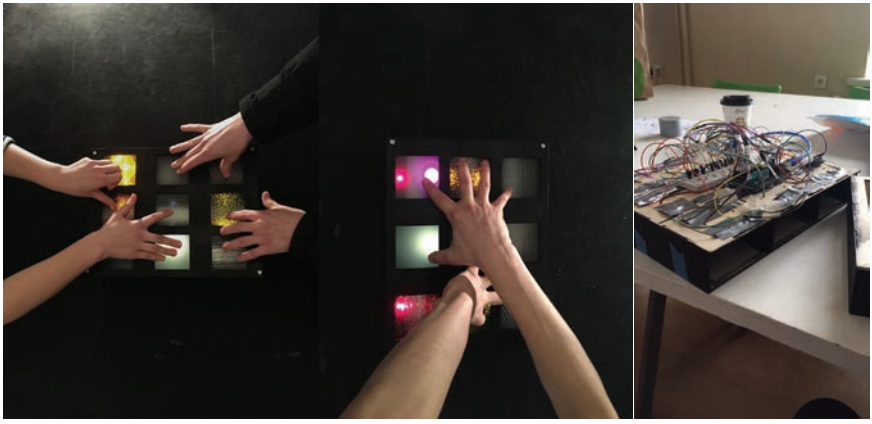

Figure 6. *MoveColour* by Julien Hac, Maarja-Liis Raamat, 2018. © Julien Hac, Maarja-Liis Raamat, and Estonian Academy of Arts.

Although *MoveColour* had used traditional textile tools such as needle, crochet hook, and sewing machine in its ideation stage, for its production it shifted to the use of digital tools such as Arduino, Solidworks, Illustrator, Indesign, Aftereffects as well as hard materials like wood and plastic and heavier tools such as the laser cutter, bandsaw, metal saw, metal guillotine cutter, handsaw, sanding machine, sandpaper, clamps, spray paint.

The skills the students pointed out that while the use of craft and digital skills are crucial for the execution of the project, soft skills including problem solving, communication, empathy, patience, creativity, and English proficiency.

Initial feedback from Support Center Juks

While handing over the artifacts to the center Juks, the staff and clients were optimistic and hopeful about the new tools arriving to their sensory room. The students demonstrated each piece and left video as well as PDF instructions together with the artifacts to the center. The immediate feedback was all positive.

However, after 4 months sensory artifacts made of hard materials had been removed from the sensory room as the room had to accommodate some newly arrived over stimulated (aggressive) clients to calm down. These clients could harm themselves and/or others. Therefore, anything that might potentially cause injury became unsuitable for the sensory room, which is meant for people with a broad autistic spectrum. Generally, the staff of Juks saw soft sensory artifacts more beneficial.

The clients really liked *Friendly Scarf*, However, when the artifact was used constantly, it unfortunately stopped working rather soon – it did not vibrate anymore when the snap buttons were closed. *TELK* has to be removed from the space because the over stimulated client might harm himself and damage the artifact. *Moodi* was with a client to learn emotions; he found some of the

expressions funny. *Off Line* was used with some clients who liked or disliked the individual artifacts. The staff of the center did not get to use *MoveColour* after the presentations as it turned out to be a bit too complicated to start and play.

Discussion and conclusion

The social design course at the Estonian Academy of Arts is an example of an interdisciplinary course allowing students in various design disciplines to learn directly from real life practice that opens up the applicability of their specialisms in a new context beyond what they are used to. By dealing with a certain group of users who may not be able to articulate how they feel about the design artifacts, students are challenged to learn to observe and be sensitive to information they have received.

The presented student work from the two consecutive years serves different target groups, however, follows a very similar design process of rough prototyping, discussions, iterative prototype refinement and presentation. The main tutor remained the same person. Additionally the second year included additional electronics tutor to assure the technical support throughout the project. The outcomes differ in their inclusion of electronic components (Table 1).

	2017 project with Mental Health Center, Tallinn Children's Hospital	**2018 project with Support Center Juks**
Target group	Children with different alertness sensitivities	Adults with autism spectrum
Duration of the course	10 weeks	10 weeks
Instructors' expertise	e-textiles + special education teacher from the center.	e-textiles + electronics prototyping + staff of the center.
Works including electronics / total works	1 / 3	5 / 5

Table 1. Comparison of the two Social Design courses at Estonian Academy of Arts.

Based on the nine-month evaluation of the 2017 project presented in the first part of the paper, technical issues arose in artifacts using electronics. The situation was probably due to the lack of time to refine the prototypes into a robust level, where they could securely work as products. As the items need gentle treatment or occasional maintenance (as can be expected from

prototypes) the context of mental health institutions might not be the best location for such items. The clients might not have all the sensitivity to treat the artifacts gently. The staff might not have the time or skills to maintain the artifacts accordingly. The authors hoped to improve the level of electronic solutions in the prototypes by involving an external electronics consultant but the works from the following year showed the same tendency when reported back after a short time of use.

Students quite often underestimate the time needed to complete a certain project. Also the short timeframe did not provide them with enough time for testing and refining the ideas before delivering their work to the client. The class could reach more finished and durable artifacts if the course lasted longer, for example 15-20 weeks. This would also allow more interaction with the partner institution to discuss, share and test the work in the actual context.

While the duration of the course is a key factor to achieved refined and durable prototypes, one interesting point that reveal in the 2018 course is the fact that several sensory artifacts had to be removed from the sensory room due to their potential harm to an over stimulated (aggressive) client. This is an important lesson learned for designing products for people with special needs. While each individual person has particular cognitive disabilities, designing for a care center and their clients mean that every single individual's cognitive ability and inability needs to be taken into consideration. An artifact designed for these people have to be 100% suitable for all.

The project has been a great real-life experience, to work with clients of extremely different backgrounds and various abilities. The students also enjoyed making social contribution and seeing their work in real use. Estonian Academy of Arts, Textile Design Department, continues to host a similar subject. In fact the collaboration currently running is in collaboration with Porkuni boarding school for children with special needs.

For the improvement of the multidisciplinary collaborative project between students and care providers, the long-term evaluation of the interactive artifacts mediating communication between persons with different cognitive abilities is essential. Items that beautifully seduce the audience during evaluation might have the opposite effect in daily life in care center and *vice versa*. It is important to understand, document and share the insights in order to develop more meaningful and useful developing tools. This social design course in the future may be designed in a way that a new group of students will have an opportunity to redesign or refine the prototypes that have been in use in either the Talllin Children' Hospital or Support Center Juks, generating a new design iteration that possibly results in a more refined and more durable products that serve their users well.

Acknowledgments

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Transdisciplinary collaboration as a new phenomenon in the Estonian design field

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Abstract

The Estonian design field is in an era of remarkable change, as the field is broadening from traditional design products and graphics to new and mostly intangible subject matters. As these new subject matters are more complex, they require increased collaboration, not only within the design discipline but across disciplines. With these changes come discussions of design's disciplinary identity, which is the aim of the current study. This paper focuses on the emerging phenomenon of transdisciplinary collaboration, in which design is in the role of innovation facilitator. To discuss this phenomenon more in-depth, the paper presents a case study of Alexela Oil, a chain of petrol stations, which partnered with two Estonian universities to explore possible visionary transformations for their business in the quickly changing and complex field of energy supply. The paper explores the collaboration through a disciplinary prism – the teamwork was built on a transdisciplinary approach. The dynamics of three different teams of designers and engineers are studied as they merged their capabilities in a unique way, team by team. This case study shows that the collaboration of experts with different backgrounds gives new, innovative impulses to the design discipline, and has created new hybrid knowledge forms, which may be a way to increase overall resilience.

Author keywords
transdisciplinary, collaboration, emerging design practices

Introduction

The problems our society is currently facing are increasingly complicated and interdependent. This ongoing process forces the research and design communities to look for new ways to deal with these complexities, as the previous approaches have turned out to be insufficient. One of the growing concerns is that professional practices are operating in professional silos, and the lack of collaboration and knowledge sharing is a restraint to successfully tackle contemporary issues, which are not isolated to particular disciplines, nor are they predictable (Klein 2004). The scope of these phenomena, with non-linear dynamics and uncertainties, extend across domains, and therefore need new research and design settings where transdisciplinarity is principal.

During the last decades, design has been expanding to new geographies by changing its nature from visible and touchable to invisible and untouchable. Redström and Wiltse (2015) claim that design has been continuously widening "its scope of concern and intervention from products to processes, experience, and entire product and service ecologies", and that design does not exist in isolation, but as part of "the intricate social and material fabric of people's lives." Manzini (2015, pp 29-31) analyses how social innovation, together with technological innovation, has been changing the design field. According to him, design by its very nature bridges the gap between social and technological systems, and as these two are going through a deep-reaching transformation, therefore design could not avoid being transformed at its roots.

If the design practise itself is under constant disruption (Binder et al. 2011 p 22), the role of the designer is transforming accordingly. Valtonen (2007 p. 81) claims in her doctoral thesis that industrial design is a professional practice that is equally affected by social, political and economic factors, and the rapid changes in Finnish context transformed the entire perception of what industrial design is and what its strategic benefits are. Lawson and Dorst (2009) emphasise that while design practice is changing quite rapidly, "the designers might find themselves in the position that they have to re-invent the very core of their professional life." Bremner and Rodgers (2013) call this "the crisis of professionalism" from several different perspectives, including professional, cultural, technological and economic forces, and therefore they characterise design by "fluid, evolving patterns of practice that regularly traverse, transcend, and transfigure disciplinary and conceptual boundaries".

The critical transformations of design disciplines make the discussion timely, as these changes require conceptualisation of design's changing nature and emerging practices. One of these emerging practices is a transdisciplinary approach, which deals with complexities, explores new and uncovered areas, produces hybrid knowledge and provides a platform for disruptive innovation. This paper takes the first step to describe and conceptualise Estonian emerging transdisciplinary design practice and discuss how it is building resilience in the current era of uncertainty and complexity. Estonian design as a disciplinary practice has not been researched so far, and this has led the new practitioners to face uncertainties in their professional careers. The analyses and conceptualisation of the emerging practice could delineate the complex and changing design scene and help professionals to understand their roles more clearly.

This paper has four parts: first, the concept of transdisciplinarity in design is introduced, then the current Estonian design context is explained and the relevance of transdisciplinarity in this context is discussed. The third section of this paper presents the case study of Alexela, and the fourth section discusses the phenomenon of transdisciplinary design practice in Estonia.

A new approach – transdisciplinarity in design

Blevis and Stolterman (2009) characterise disciplinarity as "an approach to a particular problem space using a single collection of methods within a single domain of expertise". Transdisciplinarity is not a new discipline in itself. It transcends disciplinarity by having a broader goal and by using collections of methods and range of domains of expertise. In order for a scholar or practitioner to be transdisciplinary, they need a broad perspective while remaining "disciplinary, multidisciplinary, or interdisciplinary in terms of approaches to more specific sub-problem spaces" (Blevis and Stolterman 2009). Although researchers make clear distinctions between inter-, multi- and transdisciplinarity, most of them do not see any opposition between these but consider them complementary. One of the key authors of transdisciplinarity, Basarab Nicolescu (2014), explains these differences clearly: "multidisciplinarity concerns itself with studying a research topic in not just one discipline only, but in several at the same time. Any topic in question will ultimately be enriched by incorporating the perspectives of several disciplines." Interdisciplinarity transfers methods from one discipline to another. Both multi- and interdisciplinarity have their goals within the framework of disciplinary research. Transdisciplinarity's goal is "the understanding of the present world, of which one of the imperatives is the unity of knowledge" (Nicolescu 1996). In very general terms, "trans" means moving between, across, and beyond one state to a new state. More specifically, McGregor (2014) sees transdisciplinarity as "moving back and forth between disciplines as well as moving across and beyond disciplines to engagement with the rest of the world, to a new state or a new place".

The origin of the term "transdisciplinarity" is in the literature most often traced back to the early 1970s, specifically to the OECD conference in Paris (Klein 2004). Since then, several researchers have pushed this concept further (e.g. Lawrence, Després, Nicolescu, Klein etc.) and today the field has widened significantly. Klein (2004) explains that the widening of the term is because "it is linked with comprehensive paradigms (e.g., general systems, feminism, Marxism), broad interdisciplinary fields (e.g., area studies, cultural studies), and synoptic disciplines (e.g. philosophy, geography, religious studies)".

An important aspect, why transdisciplinarity is seen as valuable, is its ability to support innovation. As Darbellay (2014) argues, transdisciplinarity "provides space for the incubation of new ideas through the introduction of nomadic concepts, theories and methods located between seemingly separate disciplinary spaces". Innovation happens because the focus of transdisciplinary research is on new areas on the periphery of the disciplines, and these areas are approached through the creative recombination and hybridisation of disciplinary methodologies. This innovative dimension is of particular interest to several researchers and to society at large, and this forces us "to rethink its foundations and, particularly, its ambiguous relationship with disciplinarity" (Darbellay, 2014).

From the literature of transdisciplinarity, the questions of disciplinary identities are often discussed and problematized. Darbellay's (2014) research of the interdisciplinary practices in Swiss universities shows that although the terms inter- and transdisciplinarity in the researched community of researchers were used, these terms as conceptual tools are not systematically discussed, negotiated or co-defined. This lack of conceptual thinking is seen as one of the vectors of "incomprehension and difficulty in the development and implementation of inter- and transdisciplinary projects". He points out that the failure of negotiating concepts in advance is one of the potential obstacles to run an interdisciplinary collaboration smoothly. This observation supports the need to describe and discuss the concept of transdisciplinarity, not only for this academic conference but for the community of transdisciplinary designers in Estonia.

Design's disciplinarity is a topic of increasing interest among several design researchers. As design's subject matters and its methodologies transition, the change of its disciplinary nature and boundaries is the focus of growing discussion (e.g. Manzini 2015, Dorst 2018, Dykes, Rodgers and Smyth 2009; Bremner and Rodgers 2013). Multi-, inter- and transdisciplinary practices force the design field to define over and over again how the boundaries of design's professional identity are constituted. New, emerging design practices that deal with new subject matters and transcend to new and undisciplined areas make the question extremely interesting and timely.

In the emerging design practices, Manzini (2016) distinguishes expert design (professional designers who are endowed with specific design skills and culture), diffused design (the natural human ability to adopt a design approach) and co-design (the design process engaging a variety of disciplines and stakeholders, including final users and design experts). He looks at co-design as a process with a transdisciplinary nature, but leaves the discussion open about the expert designer's identity and role in the process.

According to Dykes, Rodgers and Smyth (2009), the work of a transdisciplinary team is innovative, represents new knowledge, concepts and artefacts and signifies a new type of practice that is a combination of disciplinary expertise, fused together to form a newly unified hybrid form. Transdisciplinary design combines diverse disciplinary concepts to focus upon a particular context and explore new questions instead. The resulting hybrid perspective is at once between, across and beyond any one individual discipline.

From the middle of last century, design researches have been actively discussing the differences of science and design as well as describing the discipline of design (e.g. Simon 1969, Cross 2007, Lawson and Dorst 2009). Karlsson and Redström (2015) claim that design's approach to complexity is different from science, as science typically approaches through unpacking a complex whole into manageable parts. Design does the opposite in resolving societal challenges by bringing together a meaningful whole. They claim that this "putting back together again" process is far from trivial, but requires a different mindset from the start. In this paper, this way of working together is seen as one of the basics of transdisciplinary design. Transdisciplinarity involves traversing disciplinary order and deals with undisciplined areas. The focus of this article is to study this phenomenon that adopts the leading methodological framework from the design field, but syntheses others and therefore is called transdisciplinary design.

Emerging transdisciplinary phenomenon in the Estonian design context

The Estonian design field is in an era of remarkable change. At the beginning of the 1990s, there was significant turbulence as the country restored its independence, and the replacement of socialism with capitalism led to the deconstruction of existing design arrangements. This transition had enormous consequences for Estonian professional design practice, and the simultaneous arrival of digital technologies amplified the impact. A considerable number of designers lost their jobs in huge Soviet factories and could not find their place in these changed circumstances. Overall, this altered the whole perception of the design profession, as designers started to work on their own and established the first small design studios.

Almost 30 years later, the Estonian design field and design practices are still in the process of change, following similar patterns in other countries. The field is broadening from traditional design products and graphics to new and mostly intangible subject matters, like services, visions, strategies and policies. These changes are documented by a few recent papers that map the Estonian design field from an economic perspective (Veemaa, Puolokainen, Varblane and Trumm 2018, Eesti Konjunktuuriinstituut 2018). The development of a new Estonian Design Strategy has intensified the vivid discussion on designers' core competencies and professional identity, as the changes in the design discipline are still ongoing and there are disagreements stemming from educational and professional backgrounds. Therefore, it is essential to discuss these changes and conceptualise the discipline in these new circumstances, as this has not been the focus of any previous study. This bigger professional transition calls forth the discussion of design's disciplinary identity, and the current paper aims to contribute to that discussion.

This paper focuses on the emerging phenomenon of transdisciplinary collaboration, in which design has the role of innovation facilitator. The phenomenon of transdisciplinarity has emerged in the academic setting of the Design and Technology Futures (D&TF) master's degree curriculum. This 2-year master's degree program is built to combine design, engineering, future thinking and entrepreneurship. The program was founded in 2010, originally named Design & Engineering, and it is jointly run by the Tallinn University of Technology and the Estonian Academy of Arts. D&TF focuses on tackling complex contemporary issues through the emerging possibilities of design and technology.

As part of this master's program, the design studio research projects are intended to develop the capability to tackle contemporary challenges and to provide a pre-innovation set-up for the partners of academia. The challenges in the program are presented in an open format, encouraging the students' personal creative development and self-expression. Stress is made on exploratory and experimental front-end development, including analysing the problem on the ground, noticing and articulating the opportunity, generating solution ideas, prototyping, testing and validating concepts. Students are not given concrete problems to solve; instead, they work their way into complex challenges where they are trying to find room for attractive and promising interventions (D&TF 2018). D&TF is focusing on the fuzzy front-end or pre-development stage of innovation, where new possibilities are explored and

researched and where the new solutions or even types of solutions are not yet known. While in traditional design and engineering disciplines the task is given with a defined outcome (e.g. to design a new chair), D&TF aims to explore the challenge or issue from different perspectives and even from new and hybrid perspectives uncovered during the project. This setting has been researched in this paper from the transdisciplinary approach to question disciplinary boundaries and to explore the possibilities of transcending the knowledge, experience and practices of different disciplines in unknown settings and situations.

During this century, and similarly with the rest of the western world, the design field in Estonia has enlarged its subject matter from products and graphics to more immaterial end-results like systems and services, but still, these practices tend to stay into the framework of the design discipline, where design-centred knowledge, skills and experiences are practised. D&TF aims to push the boundaries of the design discipline outside of its classical form to the field where other disciplines and solutions have not worked. This aim is in line with McGregor's (2014) conceptual "blind spot" as a disruptive innovation that starts from an unexplored area of study. This is new in the Estonian context, mostly because of the overall economic context with the majority of industry focusing on providing sub-contracting services and not on developing their brands, products or services. There have been very few examples of radical innovation, meaning establishing new spheres of business or product/service categories, by Estonian companies. Therefore, D&TF can be considered a new transdisciplinary phenomenon in the fields of Estonian design and engineering.

Tackling the energy challenge: the case of Alexela

To describe this transdisciplinary phenomenon in more detail, the paper presents a case study of Alexela Oil, an Estonian chain of petrol stations, which partnered with D&TF to explore possible visionary transformations for their business in the quickly changing and complex field of energy supply. The paper explores the collaboration through a disciplinary prism. This project was set up as transdisciplinary with three separate teams working in parallel. Each team consisted of three master's students with different disciplinary and cultural backgrounds. The work during the project was documented by students and by the author of this paper. This case study focuses on exploring how the teams were working together to tackle the super-complex problems Alexela is facing and how these complexities could be turned into early-stage innovation practices.

Alexela Group operates in three main areas: energy, the metal industry and property development. Alexela Energy (part of Alexela Group) is the largest energy supplier based on private equity in Estonia. The history of the company dates back to 1964, when the Alexela Energia Reola Liquid Gas Terminal was built. Today, Alexela Energy offers innovations through simple and economical solutions for the liquefied petroleum gas (LPG), electricity and natural gas markets. Alexela operates 62 petrol stations, among these 58 are automatic stations (Alexela 2017).

The project faced two complex trends affecting Alexela's business and required intelligent and resilient solutions. First, petrol stations are focussing on selling fossil fuels, which are not considered sustainable for the future of the planet.

Secondly, the transportation sector is a major CO2 producer, while at the same time the need for transportation is growing. Alexela's collaboration project with D&TF, called Powering Tomorrow, aimed to shift the understanding of energy from invisible support to meaningful power for the future. The transdisciplinary design and engineering teams were to analyse Alexela's contexts of energy use and then introduce new concepts for products, services, systems or environments.

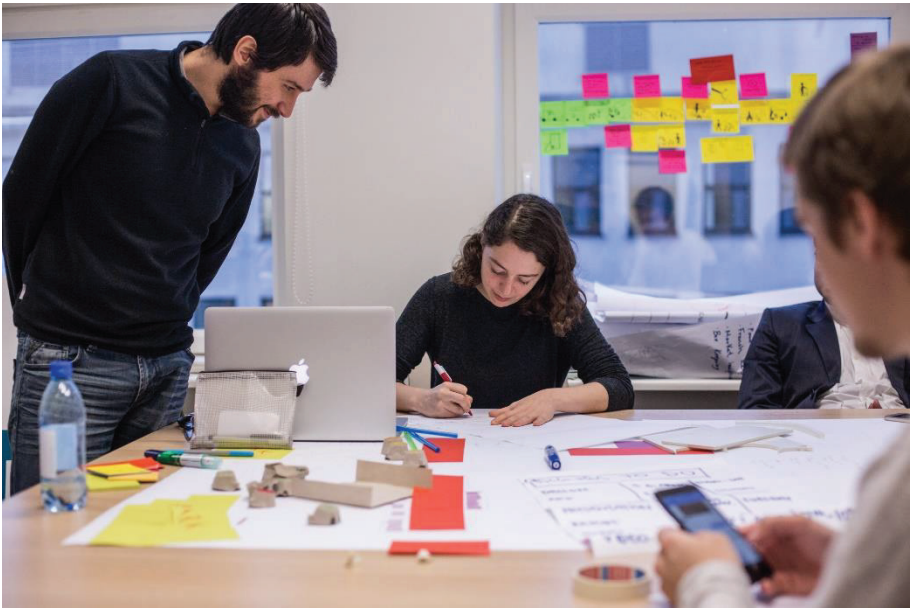

Figure 1. Team Välk's work in progress. *Photo: Evert Palmets*

As Table 1 shows, the outcomes of the projects varied significantly, although the process was similarly led by design thinking. All three teams started with analysing an existing context and situation. In collaboration, they mapped the petrol stations in Tallinn by photographing the sites and by observing people's behaviour in the stations. All three teams analysed the data from different perspectives.

Name	Outcome	Team
Välk	Välk is an autonomous wagon that charges electric vehicles no matter where they are parked. It delivers within a 100 km range in 25 to 30 minutes by utilising an optimised dc-dc power control and delivery mechanism. Välk can be employed at will via the power application on your mobile device, allowing you to sit back and let the wagon come to you.	A mechanical engineer, an engineer of communication electronics and a product designer
VeleV	The emerging variety of Light Electric Vehicles is changing the way we move in cities and this is opening up new horizons for users and service providers. VeleV is a new type of infrastructure to free us from rigid and expensive transportation systems by providing outdoor electricity for people, robots and drones.	A mechanical engineer, an entrepreneur and a designer of technical apparel
Alive	Alive is a new type of station focusing on community and the people living in the neighbourhood, considering their activities and their interests. The station acts as a meeting point for the public, offering flexible space for activities all year long. The architectural look blends into the cityscape of the community where it is located. The materials, colours and soft lines are inviting for all people, not just for car drivers.	A mechanical engineer, an engineer of communication electronics and an architect

Table 1. The comparison of project outcomes and teams. (D&TF 2018)

Team Alive noticed that all the stations are built according to the needs of car owners and the architecture of these are attractive only on the side facing the motorway. The other sides of the buildings are dark and deterring. As these stations are placed in the cityscape, these should take into account the interest of other user groups and the community around the stations. This line of thought is supported by the economic trend of Estonian petrol stations – the margins of coffee and snacks are much higher than petrol, and other user groups and local communities are becoming more critical customer segments for petrol stations than ever before. This insight gave the first perspective for the team: to change the user groups in focus and make the stations attractive for local communities and passers-by (Olivares, O., Shvets, V. and Göktürk, V. 2018).

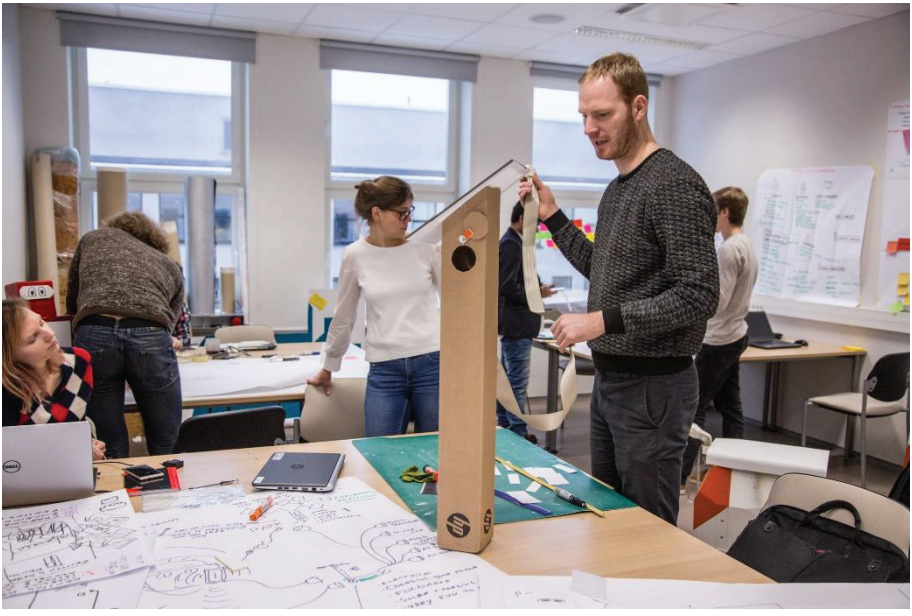

Figure 2. Team VeleV's station in making. *Photo: Evert Palmets*

VeleV's team started with analysing prominent macro trends: urbanisation, electrification and how these are affecting our everyday lifestyle towards being more sustainable and sportive. In addition, the team conducted a series of observations in public spaces, petrol stations and near public and private transportation routes in the city. The ambition was to see how people behave in the context of energy and what are the key issues they are dealing with daily. The observations showed several limitations people are facing to overcome the overall change in energy from petrol to electricity and to live healthy lives sustainably. These limitations directed the team to focus on encouraging resilient lifestyles, and they were looking at how to support light electric vehicles as alternatives for private cars and public transport in the cityscape without access to electricity (Lezdina, A., Pärtel, G. and Rosenblatt, M. 2018).

Initially, team Välk's research spanned several segments including energy mobility in the transportation sector to energy requirements in homes and in public spaces to spontaneous energy availability. Their first central perspective was the rigid nature of the energy access points in the city. As the team reported, the filling stations act as access points for people's energy needs, but their rigid nature means that people need to travel to these specific points rather than the energy being transported to them conveniently per the user's needs. Adding this to the need to reduce petrol-dependent transportation, the team continued to analyse the possibilities of how to make electricity conveniently accessible to electric car users (Khan, A., Peever, A. and Vega Anza, S. 2018).

The first research phase directed the teams to quite different routes to follow in the next, concept development phase. The research was concluded with three different aims for changing the business:

1) Alive focused on changing the meaning of a petrol station;

2) VeleV wanted to support the changing urban lifestyles;

3) Välk was looking for solutions to shift to new energy sources.

Hybrid knowledge creation

This described transdisciplinary design process showed how the team members were learning from each other and Alexela's feedback, how the discussions and visualised materials (both research materials and ideations) developed the understanding of possible design interventions and later propelled the ideas and concepts forward. As Karlsson and Redström (2015) brought out in their case study, these teams similarly were not just working in collaboration, but rather designed together by combining different views and possibilities to tackle the energy challenge. The teams entered together into the unknown process where they explored the area in question and the possibilities for future development together. All in all, it can be described as hybrid knowledge creation.

Several shared aims of transdisciplinarity can be identified in these described cases. According to Darbellay, there are two dominant orientations to transdisciplinarity. The first strand, which has an epistemological and theoretical accent, defines transdisciplinarity as "a process of knowing that transcends disciplinary boundaries, and entails a major reconfiguring of disciplinary divisions within a systemic, global and integrated perspective". In the case of Alexela's energy challenge, the process involved team members with different disciplinary backgrounds and the project diffused the disciplinary boundaries. The questions at hand were discussed from different disciplinary perspectives, but also from new perspectives which indicates the hybrid knowledge produced in the process. The second orientation in transdisciplinarity is more pragmatic, participative and applied, and focusses more on a 'problem-solving' perspective by bringing in "political, social and economic actors, as well as ordinary citizens, into the research process itself". D&TF project "Powering tomorrow" was built on the working together of team members, Alexela representatives and a wider audience. The process included user research and collaboration with experts of the field.

Most importantly, the Alexela case shows the strength of the teams as they were working together to construct new knowledge and solutions to problems that "fall outside disciplinary boundaries". The teams explored complex relations, which are woven in a dialogue between different disciplinary cultures: engineering, design and entrepreneurship. In the Alexela case, the reconfiguration and transcending of disciplinary divisions happens in and through the dialogue between scientific cultures and the resolution of societal problems, which according to Darbelly (2014) are the essential specifics of transdisciplinarity.

McGregor (2014) highlights the importance of the conceptual shift which comes along with "moving between, across, and beyond one state to a new state". The conceptual shifts were present in all three teamwork processes. It mostly emerged when applying the new perspectives to the energy challenge. They looked at the petrol station simultaneously as an energy access point, as a local community centre and as an indicator of the ending era of petrol-fuelled cars. These shiftings of view were problematic for those new to the D&TF program, and still difficult to master for the second year students. However, this can be seen as a central feature of transdisciplinary design intended to produce hybrid knowledge.

The primary goals of using transdisciplinarity, according to Klein (2014), are the following main shifts: 1) from epistemology to problem-solving, 2) from the pre-given to the emergent, and 3) from universality to hybridity and contextuality. These three shifts are the foundation of the transdisciplinary approach practised in D&TF projects and are well illustrated in this case study. At the same time, all of these three are moving the practice further from the traditional design practices, which involve pre-given contexts and operate from a single disciplinary perspective.

Estonian design's professional crisis or a new horizon?

Understanding these shifts brings the discussion back to "the professional crisis" described above, where the traditional designers are losing their ground as new design professionals differ from themselves in a significant and key way. The case study shows that Estonian design's "scope of concern" has been widened, and tackling a complex energy challenge is affecting directly and indirectly people's lives and the planet's ecological situation. Therefore, it is important in design process to combine technical innovation with changing people's behaviour. This case study showed one way it is possible – by combining the knowledge and skills of different disciplines. Instead of seeing the situation as a professional crisis, we should look at the overall rapidly changing context and the need to tackle complex challenges as a new opportunity for the design discipline. Professional silos and lack of collaboration are widely discussed as restraints to successfully tackle contemporary issues (Klein 2014), and this supporting the need for new ways of working in the Estonian design scene. This case also highlights the changed role of the designer from the star author to a team player and in this case also to the methodological leader of the process. The role of the designer varies in teams, according to the chosen approach and according to the designer's previous experience and background. This means that the designers have the potential to add a new core competency to their professional toolkit, according to their capabilities and interests and taking into account different changing perspectives, including cultural, technological, and economic forces (Lawson and Dorst 2009; Bremner and Rodgers 2013). But we can also see here the great opportunities for the wider Estonian design scene.

Conclusions

This case study shows that the collaboration of experts from different backgrounds gives new innovative impulses to the design discipline and has created new hybrid knowledge forms, which can be seen as a way to increase overall resilience. In this article, for the first time, the new hybrid identities and professional practices emerging in Estonia are described. The study of three

different transdisciplinary teams shows interesting dynamics as they uniquely merged their capabilities, team by team. At the same time, the case highlights the characteristics of transdisciplinarity practices in Estonia and shows the need to recognise transdisciplinary design as a new form of research and practice. The study illustrates how transdisciplinary research represents a new style of thought in design. The description of the new emerging practice is described and discussed to give a better understanding of the changing boundaries of the design discipline in Estonia. As the paper highlighted, the changes and dynamics in the design field call for further investigations and a rethinking of disciplinary identities.

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